1942

An evaluation of the learning ability during the various periods of the school day.

Herbert J. Sullivan
University of Massachusetts Amherst

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AN EVALUATION OF THE LEARNING ABILITY DURING THE VARIOUS PERIODS OF THE SCHOOL DAY

SULLIVAN - 1942
AN EVALUATION OF THE LEARNING ABILITY DURING THE
VARIOUS PERIODS OF THE SCHOOL DAY

by

HERBERT J. SULLIVAN

Thesis submitted in partial fulfillment of the requirements for the Master of Science degree in the Graduate School of the Massachusetts State College

Amherst, Massachusetts
1942
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CHAPTER I

THE INTRODUCTION
CHAPTER I

INTRODUCTION

In all phases of human endeavor continuous application tends in time to reduce efficiency. This may be due to one or more of many causes.

(1) Fatigue. Undoubtedly one of the principal causes for the impairment of efficiency is fatigue. The construction of the human body is such that in every twenty-four hours we must feed it and give it rest. It is only logical that through the period of time in the cycle of our daily life there is a rise and fall in its power to function.

(2) Industrial Fatigue. In industry there have been many studies and much information has been gathered concerning fatigue. It is, of course, a matter of dollars and cents with the manufacturers; and that possibly has been the stimulating influence for the research. The machine was the servant of the man when it was first developed, but now man has become the slave of the machine. - "As an attendant of the machine he must surrender himself to its time and rhythm. He supplements whatever hu-
man faculties the machine lacks. If it is without legs, he walks for it. If it lacks eyes he sees for it. He pulls, drags, lifts, if it needs arms. All of these things are done by the factory worker at the pace set by the machine and under its direction and command.¹ With the pressure of production on assembly lines, industry has found it necessary to study man's reactions and habits in order to maintain speed and avoid accidents. These studies have shown the best and poorest times of the day for accuracy and speed. A man's normal production shows a rise until the middle of the morning, then a gradual falling off occurs until the lunch hour. When he returns to his work in the afternoon he starts out at a speed slightly better than that existing when he quit at noon. A slight rise is indicated early in the afternoon and then there is a rapid decline until the ending of the work day. It is significant that accident frequency charts have an almost identical curve. Fatigue possibly has produced a lack of co-ordination to such an extent that the workers are susceptible to injury.

(3) School Fatigue. It has long been the opinion

¹Viteles, M.S. The Science of Work, p 315.
of teachers that learning during the next to the last period and the last period of the day is handicapped by fatigue. This opinion is based on observations over a period of years and may be caused, in part, by the teacher himself. The elementary school has given serious thought to the problem and has attempted to adjust its program to the high and low points of the day by scheduling the more difficult subjects during the former time and the less difficult to the latter.

(4) Shorter School Day. Assuming that we are right in our opinion that the learning efficiency is less during the latter part of the school day there has been an effort on the part of trade school teachers to shorten the day. It was learned that the length of the day was established by the Federal Government in the legislation matching state expenditures for vocational education dollar for dollar. It would be necessary to change this law to shorten the daily program, and the Massachusetts Vocational Department was unwilling to take the matter up with the National Vocational Association. They did not care to alter their policy of having a trade school program that
would simulate industrial conditions. At that time industry was commonly working a forty-four hour week. Despite the fact that in 1933 the N.R.A. made a substantial reduction in the hours worked by industry, another effort to shorten the school day failed. The state department again showed no interest.

Physical Education. Although physical education would be one way of causing a break in the long full program, our pupils have only one period every two weeks. There is no provision made for this subject during the week that the boys are in shop. It is almost futile to teach good habits of exercise when only one period out of seventy is allotted to this essential practice. This condition was recognized and in the hope of stimulating the interest of the boys, a move was inaugurated to allow them a period a day every other week for recreation. This suggestion was not received with any enthusiasm by the local authorities, but when persistence won the approval of the state department the point was carried and the recreation period became a part of the program. The period was, and still is, subject to the weather. No gymnasium
facilities are available, and it is necessary to take the groups outside. During the spring and fall there is, in the opinion of the teachers, a decided improvement in the response to the academic and related class work.

(6) Morning and Afternoon Sessions. The Chicopee Trade School is the co-tenant in one building with the Chicopee High School and the Center Junior High School. It has long been the policy to arrange schedules for the other two schools first and the trade school salvages any time and facilities that are left. This has caused, contrary to the usual practice, a short morning and a long afternoon, with the lunch period coming between the third and fourth periods. Many efforts have been made for adjustment, but without success. The completion of many a task is lightened when we can look back and see better than half of it accomplished. If the boys could have their lunch period between the fourth and fifth periods they could perhaps return to the afternoon session with more vigor, and their task would be lighter.

This would enhance the success of the academic and related work program because its nature is sedentary.
In the shops there is much more freedom and informality.

(7) A Lighter Teacher Load. For many years each teacher had a full schedule. This was not conducive to good teaching. A change was made when two new courses were added in welding and automobile body repair. Additional teachers were employed, and by combining two small classes each teacher was allowed a preparation period. This period has paid dividends by improving the morale of the teachers, and it certainly has improved the presentation of lessons. Because the teachers have been given this breathing spell they are able to present more stimulating lessons during the latter part of the day.

(8) Stagger Sessions. When a full program of seven hours a day is carried on it is the opinion of the teachers that we are not getting the proper return for energy expended in the two final periods of the day. It is necessary to make some effort to improve the conditions. In a departmental program it is obvious that the more difficult subjects should have a place in the program during the most ideal period of the day. The only way of even approaching this adjustment is a staggered schedule. This
plan, as far as can be ascertained, has been used in few school systems. There are many ways that such a program might be inaugurated. In a five period day it would run as follows:

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<th>Hour</th>
<th>Mon.</th>
<th>Tues.</th>
<th>Wed.</th>
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Such a schedule would make it possible to adjust the condition of a class having a subject requiring great mental efficiency when that efficiency was at its lowest.

(9) **Purpose of this Study.** This study is concerned with an attempt to present objective information about the value of learning during the different periods of the day. More especially, this study attempts to discover the more desirable periods in which to schedule subjects of a difficult nature. The method used in this study involves a comparison of the work between the first and other periods of the day.
CHAPTER II
RELATED LITERATURE
CHAPTER II

RELATED LITERATURE

From available information it would appear that little or no experimenting had been done in this field up to the beginning of the twentieth century. From that period Thorndike, Neck, Friedrich, Krapelin, Arai, Starch, and Ash made studies on fatigue.

(1) Fatigue and its Relationship to Learning. A summary of their work is given by Starch.² Educational and psychological literature has been replete with discussions regarding the part which fatigue plays in the reduction of mental efficiency. While psychological research has provided considerable information concerning the course of continuous work and concerning the changes in the efficiency as measured by cross-sectional tests at various stages of work, it has not furnished as yet much definite knowledge concerning the control of the work of the pupil in school. Pedagogical literature has been generous in pointing out signs of fatigue and serious consequences of overwork and in suggesting remedies for avoiding exhaustion.

² Starch, Daniel, "Educational Psychology" p 170-175.
yet we are not sure whether the so-called symptoms are indications of real fatigue or whether any serious or even mild fatigue effects ever result from the work carried out in the majority of schools.

In discussions of fatigue it is important to bear in mind two distinctions in the meaning of the term, namely, fatigue in the sense of decrease in the capacity to do work, and fatigue in the sense of decrease in, or willingness to work. The two are plainly different and do not necessarily go together. The one is actual loss in efficiency; the other is a feeling of ennui or weariness. Much of our thinking about the problem has been confused by a failure to distinguish between these two meanings. Fatigue in the former sense probably has been greatly exaggerated as an educational problem. Perhaps only in exceptional individuals is there injurious overstrain due to mental work.

The experimental methods by which the phenomena of fatigue have been investigated will first be mentioned briefly. They may be divided into two classes; (a) Indirect methods, and (b) Direct methods.

(a) Indirect methods. The principle, upon which
the indirect methods have proceeded, has been to measure some physiological or psychological functions at different points during the course of work in order to compare the efficiency of those functions on the assumption that the difference in them would be indicative of efficiency in general. One of the first methods was that employed by Griesbach, who determined the two-point threshold upon various parts of the skin at various times of the day on the belief that a decrease in sensitiveness or a widening of the threshold indicated a reduction in general mental efficiency. He had extensive comparisons among school children for the purpose of determining the amounts of fatigue produced by various types of school work, and formulated an elaborate series of conclusions with regard to them. For example, specific fatigue values were assigned by him and his followers to the different school subjects. Vannod states that mathematics, Latin and Greek produce most fatigue, and that French and geography produce least. The difficulty, however, with results of this type is that while the two-point discrimination upon the skin varies under different mental and physical conditions, it is a
rather unsafe basis upon which to make sweeping generalizations concerning the general mental efficiency of the person. In fact, the closeness of the agreement of the size of the two-point threshold with the actual amount of fatigue is too uncertain to use this function as a symptom of general mental or physical fatigue. A number of other indirect methods have been employed, such as the rate of tapping with a stylus, the variation of blood pressure, in pulse, in respiration, the range of visual accommodation, sensitivity to pain and so on. The same criticism applies to these as to the two-point discrimination. These functions may have comitant variations within rough approximations, but they are too distant to be precise indications of mental efficiency.

The use of the ergograph as developed by Mosso and his co-workers has probably been the most successful and useful method of studying problems of fatigue. As such it is, however, a direct method for investigating muscular work and fatigue and only a very indirect and doubtful method for investigating mental fatigue.

Other direct methods of a more distinct psychological character have also been employed. They have con-
sisted of the measurement of certain mental functions at various intervals in order to determine how much variation there may be in these functions and to regard them as indications of mental efficiency in general. Such tests have been made upon memory, various types of association processes, perception as measured by cancellation tests, and the like. These tests have a certain superiority over those mentioned in the preceding paragraph since they deal at least with psychological functions, but they likewise do not directly measure the course of work as it actually occurs. They have, however, been useful in comparing efficiency in the same mental capacities at various points during the course of the day.

A considerable number of researches by means of cross-sectional test methods have been carried out upon school children as well as adults. Thus, for example, Sikorski ('19) tested pupils before and after school in writing from dictation, and compared the number of errors made. Bolton ('02) measured the memory span for digits during the early and later part of the school day. Laser ('94) made a test with pupils in addition and multiplica-

3. The names mentioned here are authors of unpublished theses listed by Starch.
tion at hourly intervals. Friedrich ('97) tested 51 pupils in addition, multiplication, and in dictation exercise at hourly periods. Ebbinghaus ('97) with the aid of the teachers, gave hourly tests in immediate memory of numbers, in addition and multiplication, and in supplying words and syllables omitted from sentences. Ritter (1900) used tests in dictation of words, numbers, and sentences, and tests in cancelling letters and words.

Practically all the investigations here mentioned that were carried out reliably, agree, when interpreted fairly, in showing that efficiency in the various functions examined is changed very slightly or unappreciably during the course of the school day. Not all the investigators, however, interpret their results in this manner.

(b) Direct methods. The most fruitful direct methods of measuring continuous mental work have been the various types of mental calculations, particularly addition and multiplication. These methods have been used by Krapelin, Thorndike and Arai, Starch and Ash and others.

The remarkable results of all experiments with purely mental functions has been that mental efficiency is
reduced only very slightly even after two or more hours of very difficult, uninterrupted work. Thus in a curve the reduction in the number of additions made per thirty second, was only from 14.0 down to 13.4, or a loss of only 4.3%. Arai found even in the course of twelve hours of difficult mental multiplication that her efficiency was reduced only by about one-half. Other investigators have shown in general the same facts.

It would seem, therefore, on the basis of experimental work, that fatigue in the sense of decrease in product achieved is practically a negligible element in school work. The actual capacity to do work with the same degree of accuracy is practically undiminished in the course of the school day. Such symptoms of fatigue as have been frequently enumerated in pedagogical writings, are apparently only superficial signs of monotony, of lack or diminished interest, or of being bored by school work, and not actual signs of loss of capacity to do the work. Such statements as "I simply cannot work any longer" made after a half or a whole hour's work, are illusory and probably signify chiefly a weariness with the work which, if it must be kept
up by force of conditions, can usually be continued without difficulty or harm and usually without being seriously boresome.

The feeling of interest or satisfaction in doing work does decrease very materially as the work goes on. Thorndike (17) for example found that the satisfyingness of such work as grading compositions decreased in the course of two hours to about one-half and in the course of four hours to about one-third of the amount of satisfaction at the beginning of the period.

The feeling of weariness, from the practical side of school activities as well as of mental work generally, is, however, an important item. In a certain sense it is a real thing. Even if it is illusory it does interfere with the smooth continuation of work. But it is very likely less serious than an actual loss of capacity to do work. Practically it resolves itself into a problem of maintaining interest rather than relieving depreciation of efficiency.

That the problem is still being given thought is indicated in a more recent publication. In order to meas-

Ibid. p 154-162
ure scholastic fatigue, the author gave 789 students from a homogeneous rural community (445 boys and 344 girls aged 7 to 14) two series of tests on consecutive days, sometimes in the morning and sometimes in the afternoon class periods. The test lasted seventeen minutes and consisted of three pages of text in which the subject had to underline in different ways the sounds which changed from one page to another. No statistically reliable average differences were found between the morning and afternoon periods as to the diminution of output. Only on Saturdays was there found a general decline in the curves, but this was thought to be due to the lack of interest in the task on those afternoons, and not to physiological fatigue. Girls were consistently superior, but this was ascribed to a greater voluntary interest on their part. In general, no correlation was found between scholastic fatigue as measured by these methods and physical development. (Pignet Index) on intelligence (group test method). Further tests were made (707 students in the arithmetic series, and 53 boys in the fifth and sixth grades for other tests) at different times of the day and on different
days. The tests consisted of exercises in spelling, arithmetic, grammar, phraseology, and poetry memorizing, the test period being either five or ten minutes in duration. Yield in the afternoon periods was less than the morning ones. The optimum yield varied with the material, hour of the day, and age. Sex, intelligence, and physical development seemed to have little effect. However, the individual curve did not agree with the average curve. Contradiction between these results and those obtained in the earlier paper is explained by the factor of interest. Main conclusions are (a) the second method of measuring scholastic work by drawing a work curve is more apt to disclose scholastic fatigue; and (b) the effective element of interest, regardless of stimulus, may counteract the effect of fatigue.

(2) Fatigue and Program Making.\(^5\) It is evident that program makers in schools have recognized that there are preferred times for study during the school day. In the making of programs, or the approving of programs submitted, the principal should work with certain constructive ideas in mind. He must, of course, see that the allotted time figures out correctly, that the recesses and dismiss-

\(^5\) Cubberley, Ellwood P., "The Principle and his School" p 164-165
als come as they should, that the schedules do not conflict with assembly periods, that the maximum and minimum time allotments prescribed are not exceeded, that the work to be supervised by special teachers comes in the proper rotation so far as possible, and that the number of periods for each week are as they should be. In addition the following principles should find embodiment, so far as can be done, in the permanent programs:

1. After the opening exercises should come one of the more difficult subjects, and preferably one that is hardest for the teacher to teach.

2. Subjects requiring good muscular control, such as writing and drawing, should not immediately follow a recess period.

3. Class work in physical training should not either just precede or immediately follow a recess.

4. Something of a balance should be retained between the work of the morning and that of the afternoon, not all the
easier subjects being placed in the afternoon, though the more exacting subjects may well be placed in the morning.

5. A heavy or exacting subject, or one requiring physical activity, should not be placed immediately after lunch.

6. Subjects requiring close mental work should alternate, where possible, with subjects requiring motor activity.

The making of the daily program was, and still is, with many teachers a matter of whim, personal preference, or convenience. However, there is a vast amount of experimental data available from which guidance may be obtained, and which is well summarized in the following statements from Sears:

1. That the day's work should open with some brief but interesting and stimulating exercise which requires little mental exertion.

2. That the first lesson should be perhaps reading and spelling, that is, the simplest

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5. Sears, J.B., "Classroom Organization and Control p 266-270
of the formal subjects.

3. That the next should be arithmetic, the most difficult of the formal subjects.

4. That recreation should follow immediately, or at least soon after arithmetic.

5. That the period immediately following the morning recess should be given to arithmetic or grammar.

6. That writing should precede rather than follow a recreation period.

7. That the most difficult of the remaining studies, say grammar or history, should come between noon and the second recess.

8. That such studies as nature study, manual training, domestic science, etc., should be placed later in the afternoon.

(3) Fatigue Studies in Industry. Industry recognizes that fatigue is a factor in production and an influence on its workers. Much research has been conducted and
an attempt is being made to gather reliable material which will enable factory managers to rectify any abuses of the worker and correct the economic losses caused by physical failure.\textsuperscript{7}

There is tremendous economic waste in the annual cost to industry of excessive and unnecessary fatigue. Gilbreth, for example, ascribes to fatigue brought about by such unsatisfactory working conditions as glare, unsuitable and badly placed chairs, etc., a daily loss of 20 cents per worker in decreased production. The annual loss in the United States attributable to industrial fatigue has been estimated at approximately $2,500,000,000. Although these figures are merely estimates, they are accepted as reasonable by those concerned with the major industrial problems.

The word fatigue, as used both popularly and scientifically, relates to three related phenomena:

(a) An overt manifestation in the form of reduced output on the task, known as work decrement.

(b) A physiological state, involving changes in organic functions and the production of chemical products of fatigue.

\textsuperscript{7} Viteles, M.S., "Industrial Psychology" p 441-461
(c) A feeling of fatigue or tiredness.

However, studies in the industrial plant show a typical drop in production toward the end of a working spell which after careful allowance is made for all other factors, can only be ascribed to fatigue. The rate of production generally increases during the first few hours of the working day. Output begins to fall off after the third or fourth hour and declines more or less steadily so long as work is continued. There is a short period of increased production after the lunch hour, but this soon falls off again. Workers scarcely ever turn out as much work in the course of the post-luncheon period of work either in the day shift or on the night shift, as during the pre-luncheon spell of work.

Among physiological tests of fatigue may be noted the measurement of rate and amount of oxygen intake, the examination of pulse rate, blood pressure, vascular skin reaction tests, tests of muscular tonus and of reflex activity.

Rate of tapping, accuracy of tapping and dotting, aiming tests, steadiness tests, the measurement of co-ordi-
nation by means of the pursuitmeter; tests of oscillation and random muscular movement (restlessness), have been employed to measure psychophysical changes occurring in both short and long periods of work both in the laboratory and in the industrial situations.

Mental tests of fatigue, occurring in both muscular and intellectual work, have included simple tests of sensory discrimination, attention tests, measures of memory, imagination, and of the higher mental processes such as intellectual judgment and reasoning.
CHAPTER III

STATEMENT OF PROBLEM AND SUMMARY OF PROCEDURE
CHAPTER III

STATEMENT OF THE PROBLEM AND SUMMARY OF PROCEDURE

(1) Statement of the Problem. Is there a variability of learning in the different periods of the school day?

(2) The City and School. The city of Chicopee is situated on the east side of the Connecticut River where it is joined by the Chicopee River, just north of the city of Springfield. The city has many industrial plants of a diversified nature, with several having national importance. The population is about thirty-six thousand and as a large number are employed in the surrounding cities and towns, as well as in the local industries, no one particular interest is being served. Consequently the pupils of the Chicopee Trade School come from homes of every description with emphasis on those of tradesmen and skilled laborers. The enrolment of the school is slightly more than three-hundred.

(3) The Subjects. Four classes of boys constitutes the total enrolment of the machine shop practice course in the trade school. These classes are made up for the con-
venience of assignment to shop and classroom. There is no choice as to year in school, age on entrance, past education or marks. These groups were chosen because of the construction and the fact that they could be taught and tested by the same teacher.

The experiment was conducted over a period of twelve school days. The first groups used were A and C and the second groups used were B and D. A and B were the control groups and C and D the experimental. The control groups were taught and tested during the first period on each day and the experimental groups were taught and tested during a different period each day. Thus on the first day group A was taught and tested during the first period and C was taught and tested during the second period. On the second day A was taught during the first period and C was taught during the third. This type of work was carried on until we had a comparison between the first and every other of the remaining periods of the school day, six in all. The same schedule was carried out with groups B and D.

By arrangement with the director the teaching and testing was all done by the same teacher. Classes were ex-
changed for the whole or part of the period as was required.

(4) **Pairing of Subjects:** (a) Whole and total
groups were used. They were total A, B, C, and D, and paired
A, B, C, and D. All pairing was done on the basis of:

- Chronological age
- Year in school
- Marks received in this school

The total groups had a membership of 30, 30, 32, and 28.
The membership of the paired groups was 20, 20, 19, and 19.
Naturally the paired groups were more evenly matched.

(5) **Material:** The groups were taught and tested
in hygiene, safety, mixed sentences, substitution of sym-
 bols for numbers, and number series.

(b) The test used in comparing the first and sec-
 ond periods was in the substitution of symbols for numbers
(see Appendix 1).

(c) During the comparison of the first and third
periods they were tested on mixed sentences (see Appendix 2)

(d) For a test between the first and fourth periods
a lesson in hygiene was taught and tested (see Appendix 3).
(e) For comparing the first and fifth periods a test in number series was used (see Appendix 4).

(f) A lesson in safety was taught during the first and sixth periods and the results were tested at the end of the periods with a test made up by the teacher (see Appendix 5).

(g) The comparison between the first and seventh periods was made by again using a test in the substitution of symbols for numbers (see Appendix 6).

(b) Procedure: (a) The classes were informed that an experiment was to be carried out. The program to be followed was explained and they were impressed with the fact that they were not to regard the tests as anything out of the ordinary. Their showing would not reflect in their marks and everything was to be taken in stride as an ordinary lesson. (See discussion on motivation on page 61)

(b) On the first day of the testing the pupils were given the key to the substitution of symbols for numbers. They were allowed five minutes to learn the key. The keys were then collected and papers containing one hundred and twenty reproductions of the nine different symbols were
distributed. The class was allowed six minutes to fill in the proper numerals from memory. (See discussion regarding Reliability of Tests on page 62)

(c) On the second day the pupils were given sheets of paper containing the mixed sentences. They were instructed to study them for five minutes. At the end of that time sheets with the same mixed sentences were passed out. The pupils were to mark the unscrambled statements as being true or false. The time allowed was six minutes.

(d) During the first and fourth periods of the third day each group was taught a lesson in hygiene by the development method. After the proper information had been developed the test, made by the teacher, was given.

(e) On the fourth day the groups were given a test in number series. The sheets containing the numbers were given to the classes during the first and fifth periods and they were allowed to study them for six minutes. When that time had expired they were given time to fill in the proper numbers completing the series.

(f) On the fifth day they had a lesson in safety again taught by the development method. They were tested after all the necessary information had been developed.
(g) On the sixth day the substitution of symbols for numbers was again presented with a different set of combinations. The procedure was the same as that carried on in (b).

(h) During the next six days the procedure was repeated with the other two groups.

(7) Extent of Control: The pairing done in each set of groups served to make the classes sufficiently equivalent in chronological age; grade in school; and marks. These pairs are compared in the tables shown in Chapter V. It was felt that the total groups were so closely matched, except for more homogeneity in some instances, that the results from these groups could also be shown. These tables are also shown in Chapter V. All factors were, so far as possible, kept constant with the exception of the period of the day that the teaching and testing took place. The control groups were tested during the first period of the school day and the experimental groups during a different period each day.
CHAPTER IV

ANALYSIS OF THE GROUPS
CHAPTER IV

ANALYSIS OF THE GROUPS

In an experiment of this sort it becomes necessary to consider the relative ability of the two groups being studied. Frequently the differences are so great that the pupils must be paired on the basis of the various factors which might influence the results. Our purpose in this chapter is to compare the total groups being investigated and also to compare the selected paired pupils from the groups. The study of differences will show whether the total groups or the selected groups are to be used in comparing results. This procedure was utilized because the paired groups were so small. Had the paired groups contained thirty or forty equivalent pairs the total groups would have been ignored. The first comparisons shown are those of the whole groups A and C.

(1) Groups A and C in the various factors. The first groups used in the experiment were A and C. The comparison of the various factors for the whole group are shown in Table 1. This table gives consideration to the
factors of chronological age (given in months); grade of the pupils in school; and the marks which the pupils have received in this school. The marks were figured on the basis of five points for an "A", four points for a "B", three points for a "C", and two points for a "D". Each pupil received eleven marks making it possible for him to have a score of fifty-five.

Table I
Comparison of the whole groups A and C in the various factors affecting the experiment.

<table>
<thead>
<tr>
<th>GROUP</th>
<th>FACTOR</th>
<th>MEAN</th>
<th>STANDARD DEVIATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Chronological Age(Mos.)</td>
<td>196.17</td>
<td>8.60</td>
</tr>
<tr>
<td>C</td>
<td>&quot;</td>
<td>195.20</td>
<td>7.60</td>
</tr>
<tr>
<td>A</td>
<td>Grade</td>
<td>11.23</td>
<td>.89</td>
</tr>
<tr>
<td>C</td>
<td>&quot;</td>
<td>11.27</td>
<td>.67</td>
</tr>
<tr>
<td>A</td>
<td>Marks</td>
<td>41.40</td>
<td>4.04</td>
</tr>
<tr>
<td>C</td>
<td>&quot;</td>
<td>40.70</td>
<td>2.72</td>
</tr>
</tbody>
</table>
The figures show a difference in the means of the chronological age of .97 months and a difference in the standard deviation of 1. This indicates that although the groups are close there is more homogeneity in the C group. The comparison of the grades shows that the means are practically the same in each group although there is indication of a little more homogeneity in the second group. Again in the marks there is little difference in the means, but the standard deviation indicates that the C group is more homogeneous. The marks are probably the most important factor being considered and they should be as close as possible.

(2) Paired groups A and C in the various factors. Table II shows the corresponding figures for the paired groups selected from the whole groups A and C. The figures from the paired groups should be more consistent and the results of the testing should be more accurately interpreted. In pairing it is expected that we have two groups that will be equal in age, marks, and grade. The results of the comparison of these factors are shown in Table II. The paired groups are naturally smaller than the whole groups as some of the pupils could not be paired with others.
Table II
Comparison of the paired groups A and C in the various factors affecting the experiment.

<table>
<thead>
<tr>
<th>GROUP</th>
<th>FACTOR</th>
<th>MEAN</th>
<th>STANDARD DEVIATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Chronological Age(Mos.)</td>
<td>195.00</td>
<td>8.50</td>
</tr>
<tr>
<td>C</td>
<td>&quot;</td>
<td>195.00</td>
<td>8.50</td>
</tr>
<tr>
<td>A</td>
<td>Grade</td>
<td>11.10</td>
<td>.73</td>
</tr>
<tr>
<td>C</td>
<td>&quot;</td>
<td>11.30</td>
<td>.69</td>
</tr>
<tr>
<td>A</td>
<td>Marks</td>
<td>40.30</td>
<td>2.90</td>
</tr>
<tr>
<td>C</td>
<td>&quot;</td>
<td>40.10</td>
<td>2.92</td>
</tr>
</tbody>
</table>

In-as-much as it is necessary to have two groups, used in this experiment, as nearly equal as possible it is evident that the paired groups will better answer our purpose. This is shown by the figures in Table II. In the chronological age the means and the standard deviations are the same. In the grade there is only a difference of .20 in the means and .04 in the standard deviations. In the marks
there is only a difference of .20 in the means and only .02 in the standard deviations. It would be almost impossible to have groups that are closer in their make up.

(3) Groups B and D in the various factors. Table III will show the figures for the whole groups B and D in chronological age, grade, and marks.

<table>
<thead>
<tr>
<th>GROUP</th>
<th>FACTOR</th>
<th>MEAN</th>
<th>STANDARD DEVIATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>Chronological Age(Mos.)</td>
<td>195.89</td>
<td>10.40</td>
</tr>
<tr>
<td>D</td>
<td>&quot;</td>
<td>198.28</td>
<td>8.15</td>
</tr>
<tr>
<td>B</td>
<td>Grade</td>
<td>11.07</td>
<td>.86</td>
</tr>
<tr>
<td>D</td>
<td>&quot;</td>
<td>11.13</td>
<td>.69</td>
</tr>
<tr>
<td>B</td>
<td>Marks</td>
<td>39.64</td>
<td>4.40</td>
</tr>
<tr>
<td>D</td>
<td>&quot;</td>
<td>40.25</td>
<td>3.00</td>
</tr>
</tbody>
</table>
The figures in Table III show a difference in the mean of the chronological age of 2.39 months and a difference in the standard deviation of 2.25. This indicates that the groups are not too evenly matched in their ages and there is a tendency toward more homogeneity in the D group. This difference is not too great however. In considering the comparison of the grades we find the groups very evenly matched. The mean and the standard deviation are practically the same. The D group is more homogeneous. In the marks, the most important item, we have a difference in the mean of .61 and a difference in the standard deviation of 1.40. The D group is more homogeneous.

(4) Paired groups B and D in the various factors. Next to be considered are the corresponding figures for the paired groups selected from the whole groups B and D. It is expected that these groups, like those in Table II, will be more evenly matched. The results of the comparison of the paired groups in the factors of chronological age; grade in school; and the marks received in this school are shown in Table IV.
Table IV

Comparison of the paired groups B and D in the various factors affecting the experiment.

<table>
<thead>
<tr>
<th>GROUP</th>
<th>FACTOR</th>
<th>MEAN</th>
<th>STANDARD DEVIATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>Chronological Age(Mos.)</td>
<td>197.50</td>
<td>8.50</td>
</tr>
<tr>
<td>D</td>
<td>&quot;</td>
<td>197.50</td>
<td>7.50</td>
</tr>
<tr>
<td>B</td>
<td>Grade</td>
<td>11.13</td>
<td>.80</td>
</tr>
<tr>
<td>D</td>
<td>&quot;</td>
<td>11.03</td>
<td>.50</td>
</tr>
<tr>
<td>B</td>
<td>Marks</td>
<td>40.26</td>
<td>3.60</td>
</tr>
<tr>
<td>D</td>
<td>&quot;</td>
<td>40.16</td>
<td>3.40</td>
</tr>
</tbody>
</table>

It is again obvious, as it was in comparing Tables I and II, that the paired groups are more evenly matched. The means of the chronological age is the same. The standard deviations have a difference of 1, indicating that the D group is more homogeneous. There is a slight difference in the means and the standard deviations of the grade, with the D group being a little more homogeneous.
In the case of the marks there is only a difference of .10 in the mean and a difference of .20 in the standard deviation. The D group is a little more homogeneous, but the difference is slight. However, the tables show the whole groups in each case as being rather similar, the chief difference being that C and D tend to be more homogeneous than their corresponding groups A and B.

(5) Summary of control. The pairing of the groups served to make them close enough in chronological age; grade in school; and marks received in this school for the purpose of this experiment. However, the paired groups are rather small. For this reason the results of the whole groups were shown. In each case the whole groups were sufficiently alike, as far as means are concerned, for comparison in the experiment but the fact of greater homogeneity in the groups C and D must be borne in mind in making conclusions. All other factors, so far as possible, were kept constant. One teacher did the teaching and testing; the same work was presented and the same tests used. Every effort was made to place the pupils at ease and it was made plain that this experiment was not in the nature of an ex-
amination. This was done to avoid the psychological reaction that sometimes affects pupils when they know they are faced with an examination. Thus, the only variable would appear to be in the time of the school day in the case of groups C and D. Groups A and B were given the instruction and tests during the first period of each morning and the experimental groups, C and D, were taught and tested during a different period each day. The results of the testing are shown in Chapter V.
CHAPTER V

THE RESULTS OF THE TESTING
CHAPTER V

THE RESULTS OF THE TESTING.

This chapter contains a number of tables showing the results of the testing. In each period the classes were taught and then instructed as to the procedure to be followed in the testing. Every effort was made to have the conditions the same in all classes, with the exception of the time of the day in the cases of divisions C and D.

(1) Comparison of the first and second periods. Four comparisons were made in analyzing the various periods. They were as follows:

Total groups A and C
Paired groups A and C
Total groups B and D.
Paired groups B and D

The instruction and the testing to compare these two periods was in the substitution of symbols for numbers. A sample of the test used in the testing period is shown in Appendix 1. The results are found in Table V.
Table V
Comparison of the results of testing during the first and second periods. Groups A and B were tested during the first period and C and D tested during the second.

<table>
<thead>
<tr>
<th>GROUP</th>
<th>MEAN</th>
<th>STD.DEV.</th>
<th>STD.ERROR of MEAN</th>
<th>STD.ERROR of DEV.of MEANS</th>
<th>DIFF.of MEANS</th>
<th>CRITICAL RATIO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total A</td>
<td>97.00</td>
<td>2.50</td>
<td>1.74</td>
<td>2.04</td>
<td>2.18</td>
<td>-1.07</td>
</tr>
<tr>
<td>Total C</td>
<td>99.18</td>
<td>5.80</td>
<td>1.06</td>
<td>2.04</td>
<td>2.18</td>
<td>-1.07</td>
</tr>
<tr>
<td>Paired A</td>
<td>95.75</td>
<td>10.85</td>
<td>2.43</td>
<td>2.60</td>
<td>3.55</td>
<td>1.48</td>
</tr>
<tr>
<td>Paired C</td>
<td>99.60</td>
<td>3.56</td>
<td>0.80</td>
<td>2.60</td>
<td>3.55</td>
<td>1.48</td>
</tr>
<tr>
<td>Total B</td>
<td>102.00</td>
<td>1.90</td>
<td>0.36</td>
<td>1.40</td>
<td>2.31</td>
<td>1.65</td>
</tr>
<tr>
<td>Total D</td>
<td>99.69</td>
<td>7.25</td>
<td>1.37</td>
<td>1.40</td>
<td>2.31</td>
<td>1.65</td>
</tr>
<tr>
<td>Paired B</td>
<td>100.37</td>
<td>2.22</td>
<td>0.51</td>
<td>0.56</td>
<td>0.48</td>
<td>0.86</td>
</tr>
<tr>
<td>Paired D</td>
<td>99.90</td>
<td>1.01</td>
<td>0.23</td>
<td>0.56</td>
<td>0.48</td>
<td>0.86</td>
</tr>
</tbody>
</table>
From Table V it is evident that no reliable difference has been shown to exist between the periods one and two. In comparing the results of the testing in these two periods the critical ratios of -1.07, -.36, 1.65, and .36 have no particular significance.

To be reliable a difference should show a critical ratio of 3.00 or greater. With a critical ratio of 3.00 or greater one can say, with practical certainty, that a real difference exists. A critical ratio between 2.00 and 3.00 gives indication of a difference, but not with a sufficient degree of certainty, (chances of certainty are about 92 in 100). Since the critical ratios in Table V are all below this point one can place little reliance on any difference that may appear. For a description and interpretation of the method of compiling critical ratio see Appendix 7.

(2) Comparison of the first and third periods. The same groups are used in this comparison. The instruction and testing was in mixed sentences. See appendix 2. The instruction and testing in each instance was exactly the same for the four groups.
**Table VI**

Comparison of the results of testing during the first and third periods. Groups A and B were tested during the first and C and D tested during the third period.

<table>
<thead>
<tr>
<th>GROUP</th>
<th>MEAN</th>
<th>STD.DEV.</th>
<th>STD.ERROR of MEAN</th>
<th>STD.ERROR of DEV.of MEANS</th>
<th>DIFF.of MEANS</th>
<th>CRITICAL RATIO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total A</td>
<td>69.50</td>
<td>13.50</td>
<td>2.47</td>
<td>2.70</td>
<td>3.83</td>
<td>1.40</td>
</tr>
<tr>
<td>Total C</td>
<td>65.67</td>
<td>6.00</td>
<td>1.09</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paired A</td>
<td>66.30</td>
<td>13.60</td>
<td>3.04</td>
<td>4.50</td>
<td>1.60</td>
<td>- .36</td>
</tr>
<tr>
<td>Paired C</td>
<td>68.40</td>
<td>15.04</td>
<td>3.36</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total B</td>
<td>68.44</td>
<td>23.05</td>
<td>4.36</td>
<td>5.70</td>
<td>3.28</td>
<td>.57</td>
</tr>
<tr>
<td>Total D</td>
<td>65.16</td>
<td>20.40</td>
<td>3.61</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paired B</td>
<td>64.90</td>
<td>23.75</td>
<td>5.46</td>
<td>7.70</td>
<td>.29</td>
<td>-.037</td>
</tr>
<tr>
<td>Paired D</td>
<td>65.19</td>
<td>23.90</td>
<td>5.49</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
In Table VI we find no reliable difference between periods one and three. The critical ratios of 1.40, -.36, .57, and -.37 have no reliability or particular significance. The third period is the period before lunch and one could expect to find that the first period was preferable for teaching. However, this difference did not appear. This may be due to the fact that the fires in the building are being cleaned and the temperature is relatively low. Furthermore it is unusual to have a lunch period occurring after such a short morning session.

(3) Comparison of the first and fourth periods. The next comparison of our four groups is found in Table VII. The instruction and testing were in hygiene. This unit was introduced in the program because, (a) it is the subject normally taught to these classes in this period, (b) it utilized the full period for instruction and testing and, (c) it is a less artificial learning situation than those previously presented. The lesson was taught with the development method and the facts were brought out in that manner. See Appendix 3 for test. The instruction, testing, and time allowed for the test was the same in all instances.
Table VII

Comparison of the results of testing during the first and fourth periods. Groups A and B were tested during the first period and C and D during the fourth period.

<table>
<thead>
<tr>
<th>GROUP</th>
<th>MEAN</th>
<th>STD.DEV.</th>
<th>STD.ERROR of MEAN</th>
<th>STD.ERROR of DEV.of MEANS</th>
<th>DIFF.of MEANS</th>
<th>CRITICAL RATIO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total A</td>
<td>89.00</td>
<td>12.50</td>
<td>2.29</td>
<td>4.40</td>
<td>11.33</td>
<td>2.60</td>
</tr>
<tr>
<td>Total C</td>
<td>77.67</td>
<td>20.70</td>
<td>3.78</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paired A</td>
<td>88.25</td>
<td>17.00</td>
<td>3.81</td>
<td>5.04</td>
<td>13.45</td>
<td>2.60</td>
</tr>
<tr>
<td>Paired C</td>
<td>74.80</td>
<td>14.80</td>
<td>3.31</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total B</td>
<td>96.29</td>
<td>11.00</td>
<td>2.07</td>
<td>3.20</td>
<td>7.85</td>
<td>2.40</td>
</tr>
<tr>
<td>Total D</td>
<td>88.44</td>
<td>14.35</td>
<td>2.53</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paired B</td>
<td>94.35</td>
<td>12.15</td>
<td>2.79</td>
<td>4.05</td>
<td>2.37</td>
<td>-.58</td>
</tr>
<tr>
<td>Paired D</td>
<td>96.72</td>
<td>12.80</td>
<td>2.84</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
In Table VII we have the first definite indication of a possible difference in learning. Critical ratios of 2.60, 2.60, and 2.40 appear. While these critical ratios are not high enough for certainty, the chances are 92 out of 100 that a difference does exist. Despite the ratio of -.58 between paired group B and paired group D we can conclude that there is a possibility of the first period being better for teaching than the fourth period.

The fourth period is the period after lunch and the possible difference may be traced to the physiological effect of having just finished eating. The stomach has called for an added flow of blood to assist in the digestion of the food and the brain has been left with less blood than usual causing a lethargic condition. This condition may be strong enough to overcome the benefits of the pupils' opportunity to move around outside and get some fresh air during the lunch period.

(4) Comparison of the first and fifth periods. Learning various number series was the unit used in comparing the first and fifth periods. See Appendix 4 for the test. The results of the testing are shown in Table VIII.
Table VIII
Comparison of the results of testing during the first and fifth periods. Groups A and B were tested during the first period and groups C and D during the fifth.

<table>
<thead>
<tr>
<th>GROUP</th>
<th>MEAN</th>
<th>STD.DEV.</th>
<th>STD.ERROR of MEAN</th>
<th>STD.ERROR of DEV.of MEANS</th>
<th>DIFF.of MEANS</th>
<th>CRITICAL RATIO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total A</td>
<td>68.00</td>
<td>11.60</td>
<td>2.12</td>
<td>3.30</td>
<td>1.17</td>
<td>.55</td>
</tr>
<tr>
<td>Total C</td>
<td>66.83</td>
<td>13.70</td>
<td>2.50</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paired A</td>
<td>68.60</td>
<td>12.32</td>
<td>2.76</td>
<td>3.90</td>
<td>2.35</td>
<td>.60</td>
</tr>
<tr>
<td>Paired C</td>
<td>66.25</td>
<td>12.65</td>
<td>2.83</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total B</td>
<td>73.75</td>
<td>13.50</td>
<td>2.55</td>
<td>8.20</td>
<td>1.72</td>
<td>.21</td>
</tr>
<tr>
<td>Total D</td>
<td>72.03</td>
<td>44.50</td>
<td>7.87</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paired B</td>
<td>71.19</td>
<td>8.05</td>
<td>1.85</td>
<td>4.10</td>
<td>1.58</td>
<td>.39</td>
</tr>
<tr>
<td>Paired D</td>
<td>69.61</td>
<td>16.05</td>
<td>3.68</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
In Table VIII we find little or no difference between the learning abilities during periods one and five. It is evident that the possible physiological condition that existed during the previous period, due to the lunch interval, has worn off and the pupils are again wide awake. The critical ratios of .35, .60, .21, and .39 show no particular indication of reliability or difference between the two periods.

(5) Comparison between the first and sixth periods. In teaching and testing during these two periods the pupils were given a lesson in safety. The lesson was a development presentation on safe grinding practices, the proper operation of the machine, and cautions to be exercised. Particular emphasis was placed on the choice of the right wheel for the type of grinding being done and the avoidance of habits that would injure the wheel and endanger the operator.

The full period was used for the presentation and testing with the same procedure followed in each class. See Appendix 5 for test. The results of the testing during these two periods will be shown in Table IX.
**Table IX**

Comparison of the results of testing during the first and sixth periods. Groups A and B were tested during the first period and groups C and D during the sixth.

<table>
<thead>
<tr>
<th>GROUP</th>
<th>MEAN</th>
<th>STD.DEV.</th>
<th>STD. ERROR of MEAN</th>
<th>STD. ERROR of DIFF. of MEANS</th>
<th>CRITICAL RATIO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total A</td>
<td>71.33</td>
<td>14.15</td>
<td>2.59</td>
<td>4.40</td>
<td>4.33</td>
</tr>
<tr>
<td>Total C</td>
<td>67.50</td>
<td>19.20</td>
<td>3.51</td>
<td>5.20</td>
<td>4.33</td>
</tr>
<tr>
<td>Paired A</td>
<td>75.20</td>
<td>15.20</td>
<td>3.40</td>
<td>5.95</td>
<td>1.16</td>
</tr>
<tr>
<td>Paired C</td>
<td>69.25</td>
<td>18.10</td>
<td>4.05</td>
<td>5.95</td>
<td>1.16</td>
</tr>
<tr>
<td>Total B</td>
<td>74.64</td>
<td>15.70</td>
<td>2.96</td>
<td>4.50</td>
<td>7.92</td>
</tr>
<tr>
<td>Total D</td>
<td>66.72</td>
<td>19.00</td>
<td>3.36</td>
<td>4.50</td>
<td>7.92</td>
</tr>
<tr>
<td>Paired B</td>
<td>71.71</td>
<td>16.30</td>
<td>3.75</td>
<td>5.80</td>
<td>5.33</td>
</tr>
<tr>
<td>Paired D</td>
<td>66.18</td>
<td>19.50</td>
<td>4.48</td>
<td>5.80</td>
<td>5.33</td>
</tr>
</tbody>
</table>
One might expect to find a difference in the learn-
ability between the first and sixth periods. This difference
did not appear in the results of the testing shown in Table IX. There were critical ratios of .98, 1.16, 1.70, and .95. This indicates no proved difference between the two groups. Since this finding is contrary to professional opinion regard-
ing this period a further check was made and a possible explanation was discovered. It is customary in the Chicopee Trade School, weather permitting, to have a recreation per-
iod once each day. Usually this does not occur until later in the year but unusually fine weather persuaded the admin-
istration to allow the pupils to get out of doors earlier this year. Groups C and D had their recreation periods im-
mediately preceding the testing during the sixth period. This may have influenced the results.

(6) Comparison of the first and seventh periods. The instruction and the testing to compare these two peri-
ods was in the substitution of symbols for numbers. See Appendix 6 for a sample of the test used. The pupils were
given the keys and allowed to study them silently and were then tested. The results are found in Table X.
Table X
Comparison of the results of testing during the first and seventh periods. Groups A and B were tested during the first period and groups C and D during the seventh.

<table>
<thead>
<tr>
<th>GROUP</th>
<th>MEAN</th>
<th>STD.DEV.</th>
<th>STD. ERROR of MEAN</th>
<th>STD. ERROR of DEV. of MEANS</th>
<th>DIFF. of MEANS</th>
<th>CRITICAL RATIO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total A</td>
<td>92.50</td>
<td>12.70</td>
<td>2.32</td>
<td>3.40</td>
<td>2.50</td>
<td>0.74</td>
</tr>
<tr>
<td>Total C</td>
<td>90.00</td>
<td>11.30</td>
<td>2.43</td>
<td>3.40</td>
<td>2.50</td>
<td>0.74</td>
</tr>
<tr>
<td>Paired A</td>
<td>96.10</td>
<td>6.90</td>
<td>1.54</td>
<td>2.99</td>
<td>9.10</td>
<td>3.04</td>
</tr>
<tr>
<td>Paired C</td>
<td>87.00</td>
<td>11.50</td>
<td>2.57</td>
<td>2.99</td>
<td>9.10</td>
<td>3.04</td>
</tr>
<tr>
<td>Total B</td>
<td>97.41</td>
<td>15.05</td>
<td>2.84</td>
<td>3.50</td>
<td>8.35</td>
<td>2.40</td>
</tr>
<tr>
<td>Total D</td>
<td>89.06</td>
<td>12.20</td>
<td>2.15</td>
<td>3.50</td>
<td>8.35</td>
<td>2.40</td>
</tr>
<tr>
<td>Paired B</td>
<td>97.77</td>
<td>6.00</td>
<td>1.37</td>
<td>3.20</td>
<td>8.34</td>
<td>2.63</td>
</tr>
<tr>
<td>Paired D</td>
<td>89.34</td>
<td>12.50</td>
<td>2.87</td>
<td>3.20</td>
<td>8.34</td>
<td>2.63</td>
</tr>
</tbody>
</table>
Table X shows a decided indication of difference in learning between the first and seventh periods. Critical ratios of 3.04, 2.40 and 2.63 indicate that the first period of the day is very likely the better period for learning. A possible explanation lies in the fact that, (a) fatigue is beginning to set in and (b) that the pupils are anticipating the final bell and the freedom to pursue their own inclinations. Table XI is a summary of Tables V to X.

Table XI

A summary of the Results Shown in Tables V to X

<table>
<thead>
<tr>
<th>Periods of the day</th>
<th>Table V</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>Critical Ratios</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>A&amp;B</td>
<td>C&amp;D</td>
<td></td>
<td></td>
<td>-1.07 to 1.65</td>
</tr>
<tr>
<td>VI</td>
<td>A&amp;B</td>
<td>C&amp;D</td>
<td></td>
<td></td>
<td>-0.36 to 1.40</td>
</tr>
<tr>
<td>VII</td>
<td>A&amp;B</td>
<td>C&amp;D</td>
<td></td>
<td></td>
<td>-0.58 to 2.60</td>
</tr>
<tr>
<td>VIII</td>
<td>A&amp;B</td>
<td>C&amp;D</td>
<td></td>
<td></td>
<td>0.21 to 0.60</td>
</tr>
<tr>
<td>IX</td>
<td>A&amp;B</td>
<td>C&amp;D</td>
<td></td>
<td></td>
<td>0.95 to 1.70</td>
</tr>
<tr>
<td>X</td>
<td>A&amp;B</td>
<td>C&amp;D</td>
<td></td>
<td></td>
<td>0.74 to 3.04</td>
</tr>
</tbody>
</table>

The conclusions which may be drawn from this study are found in Chapter VI.
CHAPTER VI

STATEMENT OF PROBLEM, CONCLUSIONS

AND LIMITATIONS
CHAPTER VI

STATEMENT OF PROBLEM, CONCLUSIONS AND LIMITATIONS

Most theories in education are no longer based solely on opinion. Educational research on a scientific basis is the method employed today in order to evaluate more perfectly the benefits derived from the introduction of new ideas. In an endeavor to find the answer to the question of "Do the pupils get less out of classroom work because of fatigue, boredom, or monotony at certain times during the school day?" The following problem was evolved.

(1) The Problem. The problem which this study sought to solve was "Is there a variation in the learning ability of pupils during the school day?"

(2) Conclusions. From the evidence presented in the previous chapters it would appear that the following conclusions can be made.

(a) Very little study has been made of this very important question.

(b) No definite evidence was reached
in this study to support the contention that variability of learning does exist in fact.

(c) There were some slight indications that such a variability might be present—sufficient indication to warrant further study of this question.

(d) The method of investigation necessary for solving this question is involved and is perhaps beyond the scope of one study of this kind.

(e) There is a possible difference in favor of the earlier periods of the day over the period after the recess for lunch.

(f) There is a possible difference in favor of the earlier periods of the day over the final period of the afternoon session.
(3) Discussion. The conclusions listed on the two previous pages indicate that the technique used in this study was inadequate to solve the problem and that several changes should be made.

(a) The first change considered advisable could not be made in this instance because of the school schedule. The groups used in an experiment of this kind should be larger than those used here. If the classes involved in an experiment are small and larger groups cannot be secured because of school scheduling, then an attempt should be made to have the experiment repeated several times or to have the experiment carried on in two or three schools simultaneously.

(b) The second necessary change, and one which should have been anticipated, is connected with the poss-
It is probable that the whole period should be used for learning and testing, no more than ordinarily interested. The material should be sufficiently ordinary so as to arouse interest to negate any fatigue that might be present. In further investigation the situation that novel or interesting was the one that the students found most interesting. The situation remained the same for ten or fifteen minutes, during which time no matter how tired the students were, the novel situation could serve for ten or fifteen minutes of motivation, if it is possible.
of learning unless one has an accurate measuring instrument. The ideal situation is to teach units for which standardized tests can be procured. In the absence of these it becomes necessary for the investigator to construct his own tests. To establish the reliability of such tests is an involved process and a lengthy study in itself. There is a strong possibility that the tests used in this study were not sufficiently accurate to measure any differences that might exist and be certain of the reliability of the results.

In spite of the weaknesses in the technique the author feels that he has paved the way for further investigation of this interesting problem.
### APPENDIX 1

**SUBSTITUTION OF SYMBOLS FOR NUMBERS**

<table>
<thead>
<tr>
<th>THE</th>
<th>1 0 T L M C R B X</th>
</tr>
</thead>
<tbody>
<tr>
<td>KEY</td>
<td>1 2 3 4 5 6 7 8 9</td>
</tr>
</tbody>
</table>

```
\[ \begin{array}{cccccccc}
T & M & K & L & J & H & C & B \\
0 & 1 & 2 & 3 & 4 & 5 & 6 & 7 \\
\end{array} \]
```

```
\[ \begin{array}{cccccccc}
T & M & K & L & J & H & C & B \\
0 & 1 & 2 & 3 & 4 & 5 & 6 & 7 \\
\end{array} \]
```

```
\[ \begin{array}{cccccccc}
T & M & K & L & J & H & C & B \\
0 & 1 & 2 & 3 & 4 & 5 & 6 & 7 \\
\end{array} \]
```

```
\[ \begin{array}{cccccccc}
T & M & K & L & J & H & C & B \\
0 & 1 & 2 & 3 & 4 & 5 & 6 & 7 \\
\end{array} \]
```

```
\[ \begin{array}{cccccccc}
T & M & K & L & J & H & C & B \\
0 & 1 & 2 & 3 & 4 & 5 & 6 & 7 \\
\end{array} \]
```
**APPENDIX 2**

**MIXED SENTENCES**

The words in each sentence below are mixed up. If what a sentence means is true, draw a line under true. If what it means is false, draw a line under false.

<table>
<thead>
<tr>
<th>Sample</th>
<th>True</th>
<th>False</th>
</tr>
</thead>
<tbody>
<tr>
<td>hear with are to ears</td>
<td>true</td>
<td>false</td>
</tr>
<tr>
<td>ear gunpowder to good is</td>
<td>true</td>
<td>false</td>
</tr>
<tr>
<td>1. true bought friendship cannot be</td>
<td>true</td>
<td>false</td>
</tr>
<tr>
<td>2. good sea drink to is water</td>
<td>true</td>
<td>false</td>
</tr>
<tr>
<td>3. of is the peace war opposite</td>
<td>true</td>
<td>false</td>
</tr>
<tr>
<td>4. get grow they as children taller older</td>
<td>true</td>
<td>false</td>
</tr>
<tr>
<td>5. horses automobile an are than slower</td>
<td>true</td>
<td>false</td>
</tr>
<tr>
<td>6. never deeds rewarded be should good</td>
<td>true</td>
<td>false</td>
</tr>
<tr>
<td>7. four hundred all pages contain books</td>
<td>true</td>
<td>false</td>
</tr>
<tr>
<td>8. to advice sometimes is good follow hard</td>
<td>true</td>
<td>false</td>
</tr>
<tr>
<td>9. envy bad greed traits are and</td>
<td>true</td>
<td>false</td>
</tr>
<tr>
<td>10. grow an than strawberries oak tree higher</td>
<td>true</td>
<td>false</td>
</tr>
<tr>
<td>11. external appearances us deceive never us</td>
<td>true</td>
<td>false</td>
</tr>
<tr>
<td>12. never is man what show a deeds</td>
<td>true</td>
<td>false</td>
</tr>
<tr>
<td>13. hatred bad unfriendliness traits are and</td>
<td>true</td>
<td>false</td>
</tr>
<tr>
<td>14. often judge can we actions man his by a</td>
<td>true</td>
<td>false</td>
</tr>
<tr>
<td>15. in are always American cities born presidents</td>
<td>true</td>
<td>false</td>
</tr>
<tr>
<td>16. certain always death of cause kinds sickness</td>
<td>true</td>
<td>false</td>
</tr>
<tr>
<td>17. are sheet blankets as as a never warm</td>
<td>true</td>
<td>false</td>
</tr>
<tr>
<td>18. never who heedless those stumble are</td>
<td>true</td>
<td>false</td>
</tr>
</tbody>
</table>
APPENDIX 3

HYGIENE TEST

1. Name three ways in which a germ disease may be spread.
2. In what manner does dust circulation aid in the spread of a germ disease?
3. Milk is called the ideal food for human beings. Why may it become dangerous?
4. What is the advantage of a drinking fountain?
5. Why is it a good practice to wash our hands before we eat?
6. We make every effort to maintain ideal conditions in the classroom. What is the ideal temperature?
7. Why is it a poor health practice to allow papers to accumulate in your desk?
8. Why is it a poor practice to place things other than food in your mouth?
### APPENDIX 4

#### Number Series

<table>
<thead>
<tr>
<th>Sample</th>
<th>5 10 15 20 25 . . . . 30 . . 45</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20 18 16 14 12 . . . . . 7</td>
</tr>
</tbody>
</table>

In each row try to find out how the numbers are made up. Then on the two dotted lines write the two numbers that would come next.

<table>
<thead>
<tr>
<th>Row</th>
<th>1st</th>
<th>2nd</th>
<th>3rd</th>
<th>4th</th>
<th>5th</th>
<th>6th</th>
<th>7th</th>
<th>8th</th>
<th>9th</th>
<th>10th</th>
<th>11th</th>
<th>12th</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Row</td>
<td>8 7 6 5 4 3 . . . .</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2nd Row</td>
<td>3 8 13 18 23 28 . . . .</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4th Row</td>
<td>8 8 6 6 4 4 . . . .</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5th Row</td>
<td>1 2 4 8 16 32 . . . .</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6th Row</td>
<td>4 3 5 4 6 5 7 . . . .</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7th Row</td>
<td>16 8 4 2 1 1/2 . . . .</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8th Row</td>
<td>8 9 12 13 16 17 . . . .</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9th Row</td>
<td>7 11 15 16 20 24 25 29 . . . .</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10th Row</td>
<td>31/.3 40.3 49.3 58.3 67.3 76.3 . . . .</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11th Row</td>
<td>1/25 1/5 1 5 . . . .</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12th Row</td>
<td>3 4 6 9 13 18 . . . .</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
SAFETY TEST

1. Why is it a poor practice to use flanges of uneven diameter on a grinding wheel?
2. Why should we never substitute washers for flanges when mounting a grinding wheel?
3. What do we mean when we speak of the clearance and the relief of a grinding wheel?
4. Tell me the procedure to be followed when it is necessary to change the wheel on your machine?
5. Name three reasons why a grinding wheel sometimes shatters.
6. Why must we always make certain that we have the right wheel for the grinding machine?
7. What types of grinding require the operator to wear goggles?
8. What is the difference between vitrified bond and resinoid bond in grinding wheels?
APPENDIX 6

SUBSTITUTION OF SYMBOLS FOR NUMBERS

| THE    | R E T M D U T T J |
| KEY    | 1 2 3 4 5 6 7 8 9 |

The key is used to substitute the symbols for the numbers. The table shows the mapping of symbols to numbers.
Sample of a Complete Statistical Computation. There is much use made in this study of various statistical concepts. Many tables refer to such items as the mean of the distribution, or the standard deviation of the distribution. Presented here is a sample of the complete statistical procedure that is necessary to find these various items. The data used here is for two of the total groups.

For Total A.

<table>
<thead>
<tr>
<th>Raw scores</th>
<th>Frequency of score</th>
<th>Deviation of score from assumed average</th>
<th>Freq. times dev.</th>
<th>Freq. times square of dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>f</td>
<td>d</td>
<td>fd</td>
<td>fd^2</td>
</tr>
<tr>
<td>85</td>
<td>2</td>
<td>4</td>
<td>8</td>
<td>32</td>
</tr>
<tr>
<td>80</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td>18</td>
</tr>
<tr>
<td>75</td>
<td>7</td>
<td>2</td>
<td>14</td>
<td>28</td>
</tr>
<tr>
<td>70</td>
<td>3</td>
<td>1</td>
<td>3/31</td>
<td>3</td>
</tr>
<tr>
<td>65</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>55</td>
<td>7</td>
<td>2</td>
<td>14</td>
<td>28</td>
</tr>
<tr>
<td>50</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>45</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>40</td>
<td>2</td>
<td>5</td>
<td>10/-28</td>
<td>50</td>
</tr>
<tr>
<td>Totals</td>
<td>30</td>
<td>-3</td>
<td>163</td>
<td></td>
</tr>
</tbody>
</table>

The mean score is first found.

Mean equals, assumed mean, plus, the sum of the fd's times the interval, divided by the number of scores.\(^1\)

Thus:

\[
M = \frac{67.5 + 3 \times 5}{30}
\]

\[
= 67.5 + .50
\]

\[
= 68
\]

\(^1\)Tieg and Crawford, Statistics for Teachers p 54
The standard deviation of the distribution is found.
Standard deviation\(^2\) equals, the interval times, the square root of, the sum of the \(fd\) squares divided by the number of scores minus the correction factor\(^3\).

\[
\sigma = \sqrt{\frac{163 - (30)}{30} \times 5}
\]
\[
= \sqrt{5.43 - .01} \times 5
\]
\[
= 2.32 \times 5
\]
\[
= 11.60
\]

The standard deviation of the mean is then found.
Standard deviation of the mean equals, the deviation of the distribution, divided by the square root of the number of scores\(^4\). Thus

\[
\sigma_m = \frac{11.60}{\sqrt{30}}
\]
\[
= \frac{11.60}{5.47}
\]
\[
= 2.12
\]

For total C.

<table>
<thead>
<tr>
<th>(\bar{X})</th>
<th>(f)</th>
<th>(d)</th>
<th>(fd)</th>
<th>(fd^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>90</td>
<td>2</td>
<td>6</td>
<td>12</td>
<td>72</td>
</tr>
<tr>
<td>85</td>
<td>2</td>
<td>5</td>
<td>10</td>
<td>50</td>
</tr>
<tr>
<td>80</td>
<td>3</td>
<td>4</td>
<td>12</td>
<td>48</td>
</tr>
<tr>
<td>75</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>70</td>
<td>3</td>
<td>2</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>65</td>
<td>3</td>
<td>1</td>
<td>3/46</td>
<td>3</td>
</tr>
<tr>
<td>60</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>55</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>50</td>
<td>5</td>
<td>2</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>45</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>40</td>
<td>2</td>
<td>4</td>
<td>8/-20</td>
<td>32</td>
</tr>
<tr>
<td>Totals</td>
<td>30</td>
<td>26</td>
<td>248</td>
<td></td>
</tr>
</tbody>
</table>

\(^2\)Ibid. p 99
\(^3\)The correction is equal to the square of the sum of the \(fd\)'s divided by the number of scores.
\(^4\)Ibid. p 133
The mean score, the standard deviation of the distribution, and the standard deviation of the mean are all found for the second group in the same manner as has been indicated for total A. Thus

\[ M = 62.5 + 4.33 = 66.83 \]
\[ \sigma = 2.74 \times 5 = 13.70 \]
\[ s_m = \frac{13.70}{5.47} = 2.50 \]

For a comparison of the two groups.

The difference between the mean scores of the two groups is found. Thus

\[ D = 68 - 66.83 = 1.17 \]

The standard deviation of this difference is found.

Standard deviation of the difference equals, the square root of, the sum of the squares of the standard deviations of the mean of the two distributions\(^5\). Thus

\[ s_d = \sqrt{s_m^2 + s_m^2} = \sqrt{2.50^2 + 2.12^2} = \sqrt{6.25 + 4.49} = \sqrt{10.74} = 3.3 \]

The critical ratio of the difference is found.

The critical ratio is the relation of the point difference between the means to the standard deviation of this difference\(^6\). Thus

\[ C. R. = \frac{1.17}{3.3} = .35 \]

\(^5\)Ibid. p 139
\(^6\)Ibid. p 140
There is little material on this particular subject. However, in the following books, one may find some information on fatigue, monotony, boredom, and the arrangement of the curriculum to compensate for those periods of the day when the pupil is not expected to be in a condition to apply himself successfully to an exacting study.


